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EMPLOYMENT AND COMMAND AND CONTROL FOR THE NON-LINE-OF-SIGHT (NLOS) MISSILE SYSTEM

by

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Employment and Command and Control for the Non-Line-of-Sight (NLOS) Missile System

by

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Captain, United States Army
B.S., United States Military Academy, 1980

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of the requirements for the degree of

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ABSTRACT

The author describes the employment and command and control of the Non-Line-of-Sight (NLOS) missile system. A history of the system portrays NLOS as a weapon system still in the early stages of development. A detailed description depicts NLOS as an application of fiber optic technology enabling the engagement of helicopters and ground targets beyond visual range. The plan to organize and employ NLOS in separate units (anti-air and anti-tank) at the maneuver brigade level is described. Command and control of the system is discussed in the context of its employment as a dual capable system at the maneuver brigade level and in the context of a definition of command and control. Early command and control testing for the NLOS system is discussed and some of the results of that testing provides the basis for the following conclusions: The employment of NLOS at the maneuver brigade level should work with the exception of NLOS-AT (anti-tank) units being used to engage helicopters; the employment of NLOS-AD (air defense) in the air role is heavily contingent on the development and successful integration of masked target sensors into the Forward Area Air Defense Command, Control and Communications (FAADC2I) system; and the lack of weapon system hardware and proposed automated command and control systems for the NLOS system precludes a definitive evaluation of command and control at this time.

TABLE OF CONTENTS

I. BACKGROUND

A. PURPOSE AND INTRODUCTION

The purpose of this thesis is to analyze employment and command and control for the Non-Line-of Sight (NLOS) weapon system. The NLOS missile system utilizes fiber optic technology to engage both rotary wing and armored ground targets beyond the visual range of the gunner. Since 1982, when the missile system was first demonstrated to the Army, many documents have been published in regard to how the NLOS system should be organized and fought. Because the weapon system is capable against both helicopters and ground targets there are many opinions as to how it should be employed. Questions regarding command and control of the NLOS system have arisen because of the system's dual capability, and because of the uncertainty involved with its employment. The remainder of Chapter I provides a history of the NLOS system and a detailed system description.

B. HISTORY

Fiber Optic Guided Missile (FOG-M) technology was first demonstrated in 1982 by the Research Development and Engineering Center of the U.S. Army Missile Command (MICOM,RDEC). In the three years that followed several army combat arms schools showed interest in the new technology, but it was not until the Infantry School developed the Advanced Anti-tank Weapon System-Heavy (AAWS-H) in 1985 that a proponent proposed an actual mission need for the weapon. The AAWS-H concept provided a mix of six long range anti-tank (LRAT) systems and six Kinetic Energy Missile (KEM) systems. The leading candidate for LRAT at that time was considered to be the FOG-M.

As a result of the cancellation of the Sergeant York Gun in August of 1985, the U.S. Army was left without a planned way to protect forward deployed troops against enemy attack helicopters. The Air Defense Artillery (ADA) Branch was immediately directed to perform a reassessment of all Army Air Defense with primary focus on the late 1990's. This reassessment, termed the ADA Laydown, concluded that the way to meet the threat of the late 1990's against our forward deplayed troops was a mix of weapons and sensors tied together by a robust command and control system. Thus, the Forward Area Air Defense System (FAADS) was conceived and adopted as not only the replacement of the Sergeant York, but the mainstay of the Air Defense Artillery Branch well into the 1990's and beyond. The FAADS system is depicted in Figure 1.

FAADS was to consist of five components: a non-line-of-sight missile; a forward line-of-sight-heavy component; a line-of-sight-rear component; a command and control network; and the combined arms initiative. In November 1987, the Army announced the selection of Martin-Marietta's Air Defense Anti-tank System (ADATS) to meet the forward line-of-sight-heavy requirement. The Pedestal-Mounted Stinger (PMS), built by Boeing Aerospace, was picked as the line-of-sight-rear component. The command and control network called for the gradual deployment of $2.5 billion worth of sensors, radars, and communications equipment. The combined arms initiative is an effort to equip other battlefield systems with an air defense

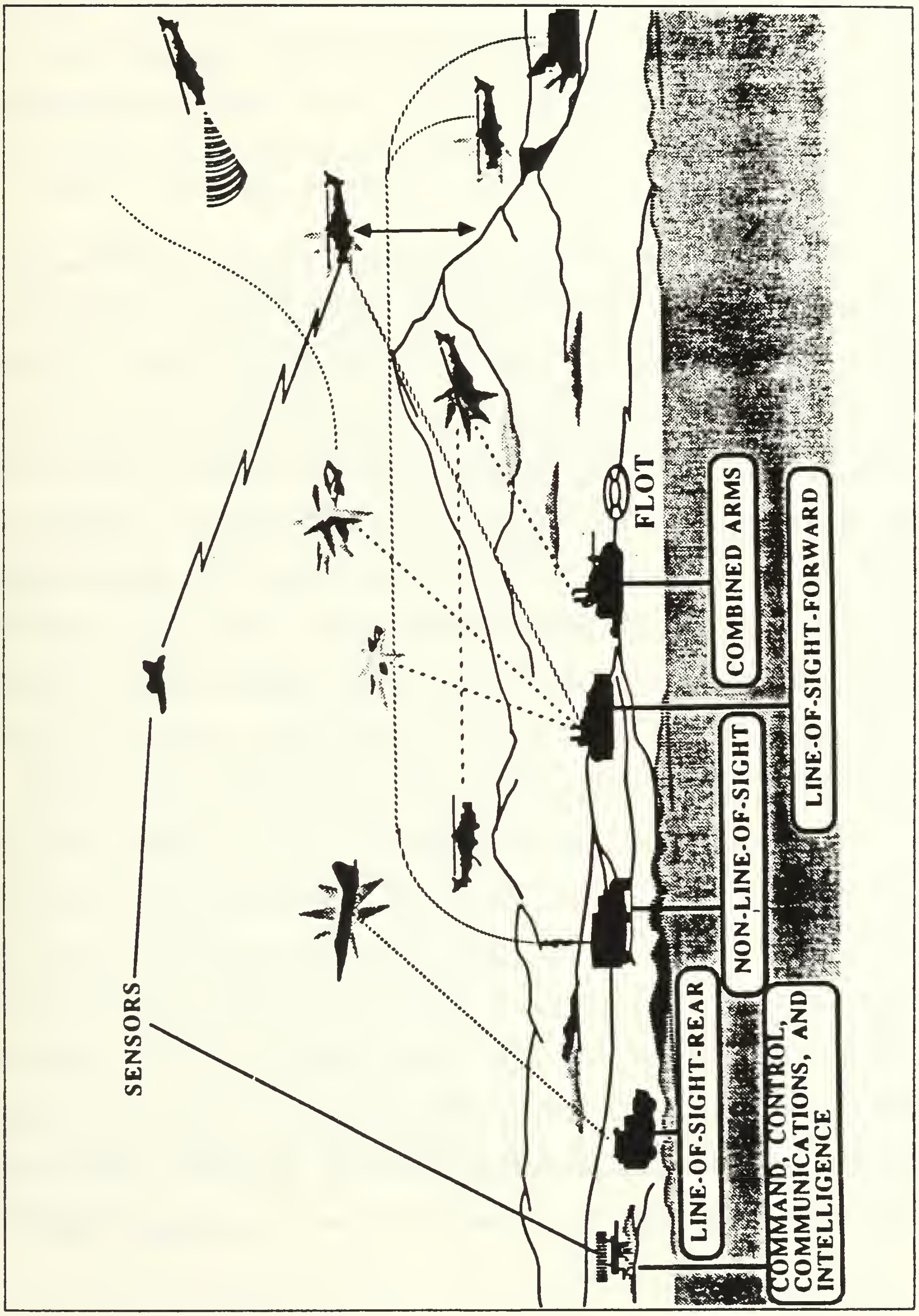

Figure 1. The FAADS System

capability. For example, the Bradley Fighting Vehicle is to be equipped with an air defense sight and the M1 tank will fire a special 120 mm round designed to destroy helicopters. The FOG-M was chosen as the non-line-of-sight component, and thus the Infantry School and the Air Defense School both laid claim to the weapon.

In September of 1986, the Army decided that rather than having two separate programs for NLOS it was more practical to have just one program. The Air Defense School was chosen to pioneer the NLOS effort. In order to simplify requirements and gain approval for the weapon system only air defense mission needs were addressed and all references to anti-tank (AT) requirements were omitted. The AT requirements were to be included at a later date as an appendix to the Non-Line-Of-Sight Air Defense Required Operational Capability (NLOS-AD ROC). While this approach may have accelerated approval of the FOG-M as an air defense weapon in the near term, the Department of the Army was to learn that long term approval for the weapon would be contingent upon AT requirements being included.

In December 1988, Congress decided that funding for the NLOS program should be contingent upon the system being fielded for both air defense and AT roles. As a result, the Department of the Army presented a dual-capable system concept to the Defense Acquisition Board (DAB) for a Milestone II decision in August 1988. The dual concept continued to give Air Defense the lead in NLOS proponency. The DAB agreed to the new concept and made the decision to proceed with full-scale development. In December 1988, the full-scale development contract was awarded to the team of Boeing/Hughes.

Currently, Force Development Test and Experimentation (FDTE) is scheduled for October 1991 and Initial Operational Test and Evaluation (IOTE) is scheduled for July 1993.

C. WEAPON SYSTEM DESCRIPTION

1. General

NLOS is a fiber optic guided missile system capable of engaging both rotary wing and armored targets (stationary or moving) at extended ranges (15-25 km). Once launched, the missile flies a non-ballistic trajectory (altitude 100-300 meters), thereby reducing the chances of radar detection and increasing the survivability of the missile crew. During flight, the missile transmits TV data back to the gunner allowing him to "see what the missile sees." As a result, NLOS can engage targets hiding behind obstacles. The system can launch up to three missiles at three different targets within a given target array. Additionally, the image generated by the seeker may be recorded and played back for damage assessment and battlefield information purposes. The NLOS weapon system is made up of three elements: expendable missiles, a ground control station, and a two-way fiber optic link (one link per missile) that transmits video from the missile seeker to the gunner and guidance commands from the gunner to the missile. Since NLOS will be fielded in both light and heavy divisions, there are two variants to the system. The NLOS (light) system is mounted on the High Mobility, Multi-purpose Wheeled Vehicle (HMMWV) and can have up to six missiles (Figure 2).

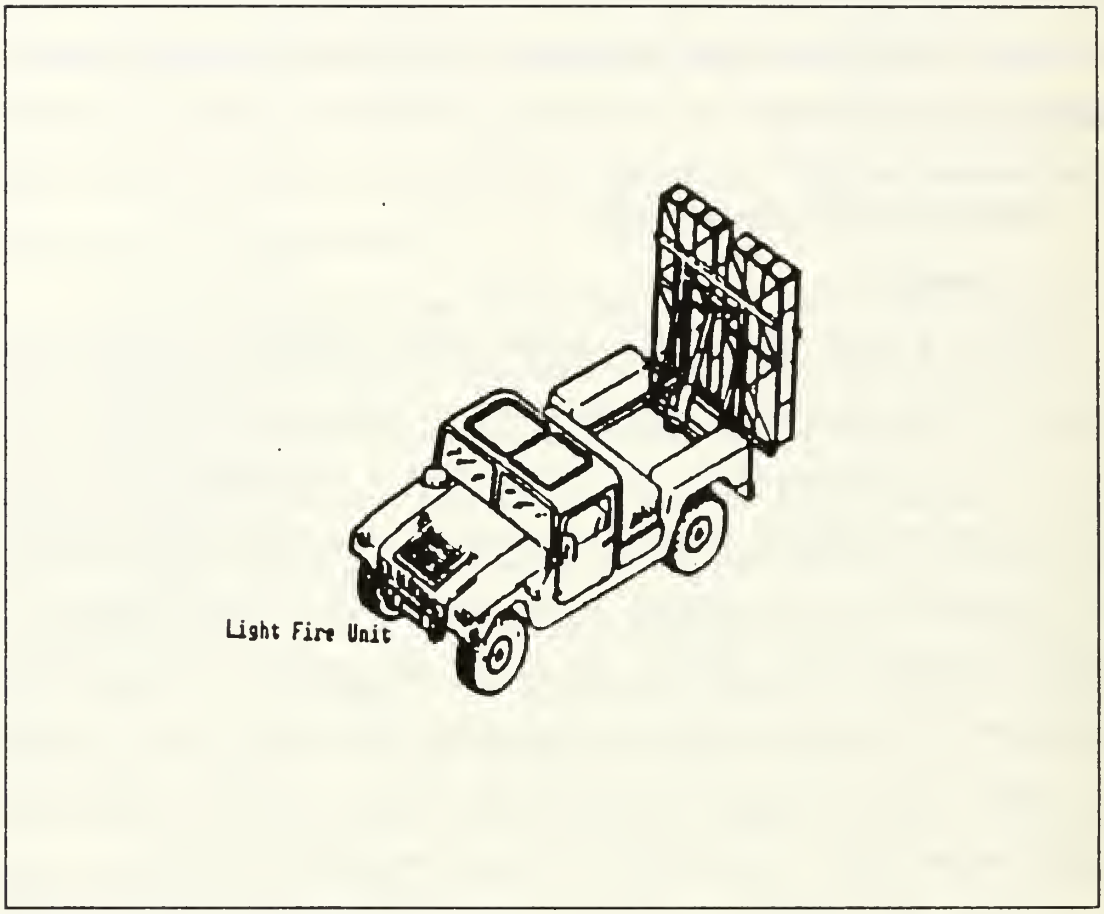

Figure 2. NLOS Light Fire Unit

The NLOS (heavy), which will be deployed with armored and mechanized units, is mounted on a Multiple Launched Rocket System (MLRS) tracked vehicle chassis, and can have up to twelve missiles (Figure 3).

2. The NLOS Missile

The NLOS FOG-M missile is packaged in a Launch/Storage Cannister. It is planned that no maintenance will be required throughout its ten year service life. In the current design, the missile is partially erected prior to

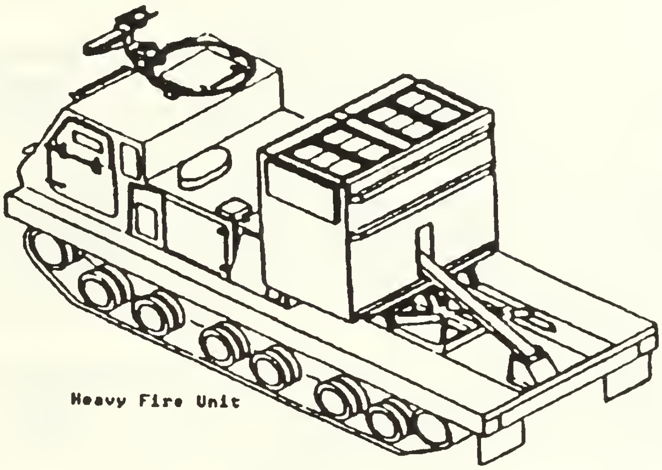

Figure 3. NLOS Heavy Fire Unit

launch and the wings are deployed in flight. As depicted in Figure 4, the nose of the missile contains a stabilized gimbal assembly capable of supporting either a television (TV) or imaging infrared (IIR) sensor. Inertial guidance sensors provide stabilization for the missile and seeker, while at the same time providing inputs to the missile guidance system on the ground. The missile warhead is located behind the seeker and is capable of defeating armored ground targets as well as helicopters. Powered by a turbojet motor, the missile is capable of a maximum cruise velocity of 170 meters per second. During target search, however, it slows to a speed of approximately 100 meters per second. The fiber optic data link is located at the rear of the missile and is payed out during flight.

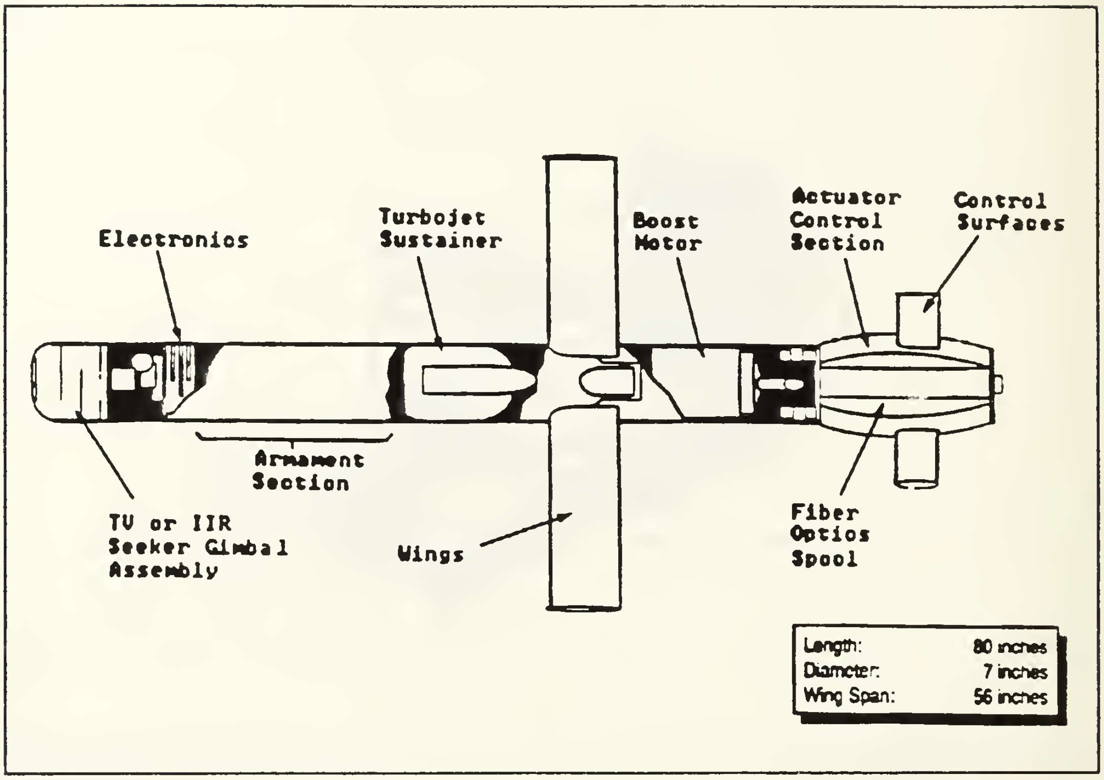

Figure 4. The NLOS Missile

3. The Ground Control Station

a. *The System Controller Unit*

The SCU performs functions such as missile navigation, pre-launch route planning, and launch as well as providing interfaces to each of the peripherals. It is the heart of the ground control station.

b. *The Digital Map Generator (DMG)*

The DMG provides the gunner a digital terrain map which is displayed on the gunner's console. This map is used to assist the NLOS fire unit in navigating to the launch site and to plan missile routes from the launch site to the target areas.

c. The Ground Electro-Optical Unit (GEU)

The GEU receives the video and missile sensor data at the ground control unit and transmits the missile and seeker control commands. These commands include navigation, propulsion control and seeker field of view (FOV), and gimbal position commands.

d. The video Storage Device (VSD)

The VSD records missile video and provides the capability to play back what the seeker viewed during flight for damage assessement and battlefield information purposes.

e. The Autotracker/Video Signal Processor (VSP)

The VSP provides realtime tracking of targets and performs seeker video processing. Additionally, the VSP performs target acquisition and TV seeker zoom control when in the autotrack mode.

f. The Gunner Console

The gunner console enables the gunner to perform a myriad of functions and represents the focal point of the man-in-the-loop interface to the NLOS system. These functions include viewing missile video, route planning, launch control and manual missile control.

4. The Fiber Optic Data Link

The fiber optic data link accomplishes simultaneous two-way transmission through the use of independent wavelengths for uplink and downlink signals. This link is used to transmit seeker video and sensor data to the ground control station while simultaneously relaying missile guidance commands to the missile. The use of fiber optic technology provides some inherent benefits. Since fiber optics is a non-radiating medium, immunity from detection is achieved and the effects of Electromagnetic Interference (EMI) and Elecrtromagnetic Pulse (EMP) are avoided. Additionally, environmental effects like rain attenuation and ducting do not adversely effect performance.

5. System Limitations

The NLOS system has no inherent means of target acquisition. Its integration into the FAADS system will provide target acquisition via the FAAD Command, Control and Intelligence (C2I) network, and call for fire radio nets will provide target cueing. Additionally, an onboard sensor is planned in the near future.

6. A Typical Fire Mission

Upon arrival at a new location, the NLOS gunner will receive information regarding his fire unit's assigned target area from higher headquarters. He then calls up the digital terrain map on the gunner's console and procedes to pre-program missile routes into the target area. This is done to ensure that the missile avoids collision with prominant terrain and to take advantage of terrain features to minimize the probability of target detection. The gunner will receive target information from any one of a number of cueing means. Once a target location is determined, the gunner can have the first missile in flight in a matter of seconds. The missile, once launched, will automatically fly the pre-programmed route. A thin optical fiber is payed out the tail end of the missile as it flies toward the target. This optical fiber remains connected to the ground control station and provides continuous two-way, broadband communications between station and provides continuous two-way, broadband communications between the missile and the gunner. The gunner is able to view video from the TV or IIR camera mounted in the nose of the missile, and has the capability to slew the seeker in both azimuth and elevation to search the entire area in front of the missile. Upon the missile's arrival in the target area the gunner locates and positively identifies the target by controlling the seeker's fields of view and look angles. At this point the gunner initiates track on target and the missile is guided to intercept by the autotracker in the fire unit. Once the gunner initiates track on target, he is free to turn his attention to a following missile. The NLOS system allows for multiple missiles in flight, each flying pre-programmed routes. The NLOS engagement concept is diagramed in Figure 5.

7. Thesis Organization

Chapter II discusses the planned employment concept which lays the foundation for a discussion of command and control of NLOS in the following chapter. Chapter III begins with a definition of command and control and proceeds to describe the NLOS command and control concept in consonance with the definition. Chapter IV discusses some testing that has been conducted in an effort to evaluate NLOS command and control and is the primary source for concllusions drawn in chapter V.

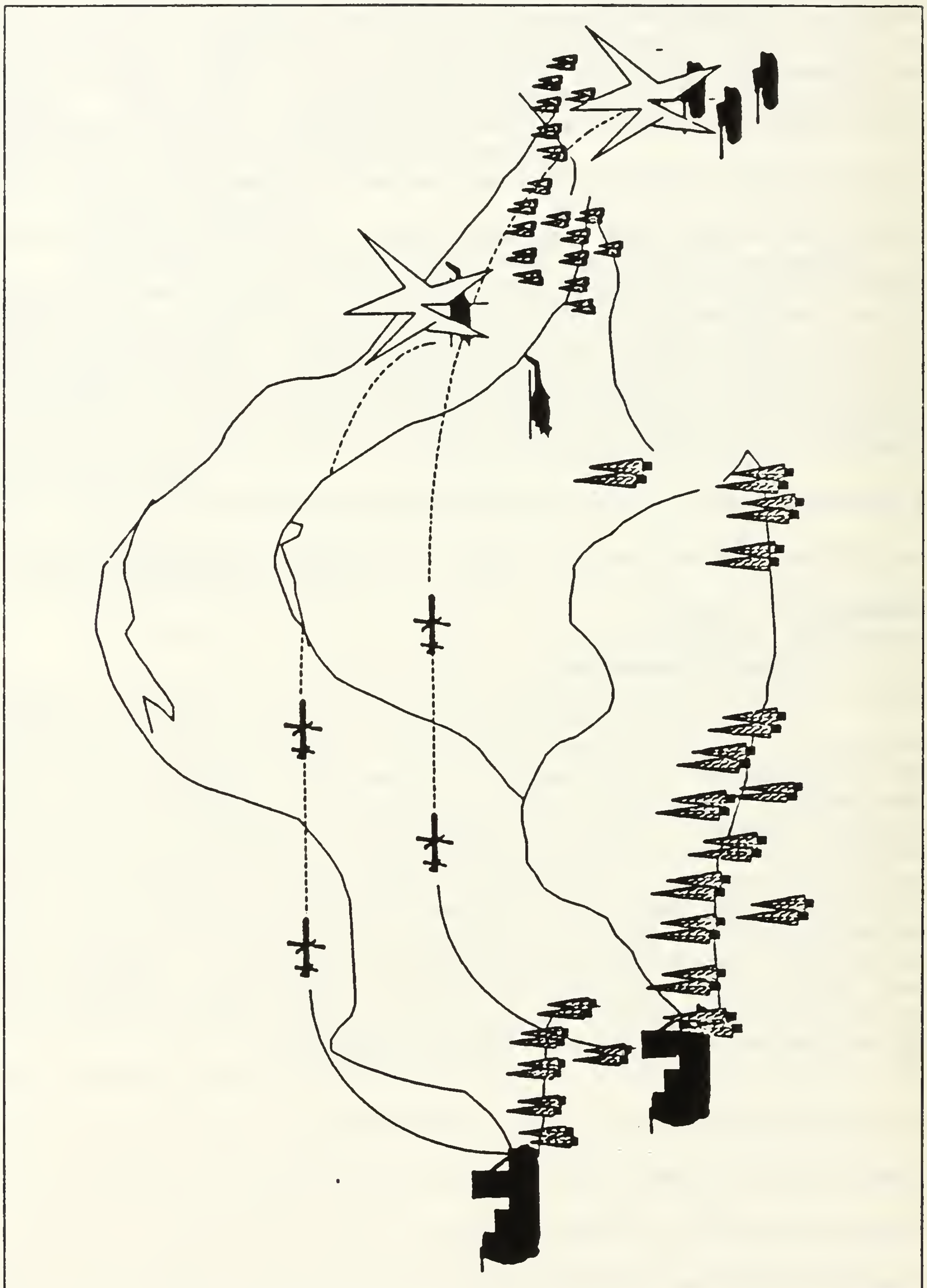

Figure 5. NLOS Engagement Concept [Ref. 4:p. 1-2]

II. ORGANIZATION AND EMPLOYMENT

A. EVOLUTION

The Air Defense Artillery School released a document entitled Air Defense Artillery Non-Line-of-Sight FOG-M, Red Paper, Tactics, Techniques and Procedures in August 1988. This document, called the Red Paper for short, detailed the Air Defense view on how to organize and fight NLOS on the battlefield. Since the NLOS-AD ROC addressed only Air Defense requirements, it is not surprising that the Red Paper did not include a detailed analysis of how to employ NLOS in the anti-tank role. NLOS was, naturally enough, portrayed as an essential element in the FAADS Battalion organization. Because NLOS has a dual capability against helicopters and tanks, the Red Paper oulined a procedure by which missiles were to be allocated for both roles. According to this procedure, the ADA commander (the FAADS battalion commander) would make an assessment of the air threat based on intelligence preparation of the battlefield (IPB), and other intelligence sources. He would then allocate two missiles per airframe [Ref. 1:p. 4-15]. The next step would be to multiply the total number of allocated missiles by two to provide a one hundred percent redundancy for NLOS in the air defense role. This would account for attritted NLOS fire units and make up for the fires that would be lost due to displacing units. Then:

> After all these factors are considered and ADA missiles allocated, then the remainder will be used for ground targets. The ADA commander will

> notify the FSE [Fire Support Element] on the number and geographical locations of missiles dedicated to ground firing. [Ref. 1:p. 4-16]

This allocation concept obviously supports the notion that NLOS is primarily an air defense weapon system with secondary role against ground targets.

At the same time the Air Defense School was developing the Red Paper, the Command and General Staff College (CGSC) was working on an employment concept based on the congressional guidance to utilize the system as part of the Army's anti-armor modernization plan. In July of 1988 the CGSC Non-Line-of-Sight NLOS White Paper was released, detailing the employment of NLOS in a dual, combined arms role. The White Paper emphasized both Air Defense and ground roles for NLOS, with the degree to which the system was to be employed in either role determined by the the factors of METT-T (Mission, Enemy, Terrain, Troops, and Time). As far as organization was concerned, the White paper considered whether or not it was suitable to employ NLOS in separate organizations for air defense and for fire support against ground targets. Additionally, the White Paper looked at three alternatives regarding at what level the weapon system should be organized: division; brigade; or organic to maneuver battalions. In the end, the following recommendation was made:

> Given the current constrained budget, separate organizations to conduct ADA, FA [Field Artillery], and direct fire missions does not appear prudent. This paper recommends that NLOS be organized in a separate organization at the division level. [Ref. 2:p. 8]

This recommendation essentially meant that the FAADS Battalion organization, as already approved and funded, should remain unchanged. The dual role of NLOS as portrayed in the White Paper dictated, however, that missile allocation be accomplished in a more equitable manner than the plan established in the Red Paper. Missiles would be allocated by the maneuver brigade commander, with the split between those allocated to air versus ground roles being determined by careful analysis of the potential threat, and the mission at hand. Along with the change to the missile allocation scheme, the White Paper stressed the importance of coordination and intelligence when fighting NLOS in the dual role:

> Accurate and timely intelligence and coordination with the FA fire support coordinator, aviation LNO [Liaison Officer], USAF TACP [United States Air Force Tactical Air Command Post], and others is critical for successful NLOS employment. [Ref. 2:p. 17]

The maneuver brigade tactical operations center (TOC) is the lowest level where the above coordination may be accomplished because the Air Force is not represented at lower levels. The NLOS platoon leader, located at the brigade TOC, would necessarily be the focal point in the process. More detail concerning this process will be provided in Chapter III, " Command and Control."

While the White Paper did address the dual role of NLOS in detail, it was still not clear to some in the Army that the anti-tank role of NLOS was sufficiently developed. The Training and Doctrine Command (TRADOC) commander, General Maxwell Thurman, directed that a study be conducted to examine the possibility of forming a direct support, indirect fire, support battalion for maneuver brigades. The proposed battalion was to consist of howitzers, heavy mortars, and an NLOS-CA (Combined Arms) element. In response to General Thurman's tasking, a group called Close Support Study Group IV (CSSG IV) was formed. The group consisted primarily of Field Artillery officers, however, the Armor school, the Aviation school, the Air Defense school, and the Military Intelligence school also were represented.

The group was given detailed briefings on the NLOS system, after which an attempt was made to "...develop an employment concept that would maximize the impact of the system on the battle." [Ref. 3:p. 4-1] The group's findings were published in a report released in June 1989. Key among the group's recommendations was that there was a requirement for separate organizations to accomplish the anti-tank and air defense missions. The group suggested that because the targets that NLOS would have to engage in the dual role are so distinctly different (ie. fast-moving helicopters and slow moving armored vehicles and formations), and because the target identification skills required in the engagement of air and ground targets are so fundamentally dissimilar:

> Anti-tank NLOS organizations be established that are distinct from air defense NLOS organizations. Each type organization will take on the opposite mission as a separate task. [Ref. 3:p. 4-5]

A separate conclusion of CSSG IV was that NLOS-AT (anti-tank) is a "...fire support system best controlled by the fire support command and control system." [Ref. 3:p. 4-1] Based on this conclusion and other factors, the group recommended that the "Field Artillery Branch is the appropriate branch for proponency of the NLOS-AT system." [Ref. 3:p. 4-1]

The Combined Arms Developments Activity (CACDA) published the Combined Arms Operational and Organizational Plan (O&O Plan) on 28 June 1989, which officially documented the Army's requirement for NLOS-AT. The O&O Plan outlined an NLOS-CA concept, consisting of two separate entities: NLOS-AD and NLOS-AT. The NLOS-CA concept was fully developed in a document entitled <u>NLOS-CA Tactics, Techniques and Procedures (TTP)</u>. While the NLOS-CA TTP covered NLOS-AT in great detail, the document referred the reader to the Air Defense Red Paper for specific techniques for NLOS-AD employment. Before covering NLOS-CA in detail, it is necessary to describe the threat that the concept was designed to defeat.

B. THE THREAT

1. The Ground Threat

Soviet/Warsaw Pact forces stress large, conventional mechanized forces and the massing of overwhelming combat power at the critical place and time. Timing, heavy artillery preparation, and the echelonment of forces are seen as critical elements in the execution of combat operations. Second echelon forces are utilized to reinforce the successes of first echelon units to strike deep into the opposing force's lines. If the Soviet second echelon forces are allowed to follow behind the first echelon forces unchecked, the Soviet commander is able to retain the initiative and gain the numerical superiority he needs for success. If Soviet artillery is allowed to engage high priority targets such as command and control centers and friendly air defense units, the Soviet commander gains a significant advantage also, and is much more able to dictate the time and place of battle. Engagement and disruption of second echelon forces, field artillery units, and other high value targets allows the defending commander to gain the time and space necessary to maneuver his forces and seize the initiative. NLOS-AT is ideally suited for engagement of these deep targets beyond line of sight.

2. The Air Threat

According to U.S. Army doctrine a defending brigade should be able to defeat an attacking Soviet division. A Soviet division has an assigned aviation squadron with between ten and twenty attack helicopters. A Combined Arms Army (CAA) has an aviation regiment with sixty helicopters assigned. It is estimated that a U.S. brigade in defense against a CAA main attack could see as many as fifty to sixty attack helicopters. [Ref. 2:p. 1] Soviet attack helicopters, with lethal anti-armor munitions and heavy armor protection, pose perhaps the most serious threat to forward deployed units on the battlefield. The speed with which they are able to ingress and egress a brigade area of operations, coupled with their ability to fly nap-of-the-earth profiles, makes early detection and engagement crucial. Countering the Soviet rotary wing threat is the primary mission of NLOS-AD.

C. NLOS-CA ORGANIZATION

According to the NLOS-CA TTP manual, NLOS-AD and NLOS-AT are organized as separate units. Figure 6 depicts how NLOS-CA is organized in the heavy division. The FAADS battalion has three batteries, each with a platoon of six launchers for a total of eighteen NLOS-AD fire units in the division. NLOS-AT, organized in a separate divisional battalion, is comprised of three batteries with three platoons each. Each platoon has four sections which results in 36 NLOS-AT fire units in the division. NLOS-AT batteries will be task organized to maneuver brigades by the division commander depending on the tactical situation.

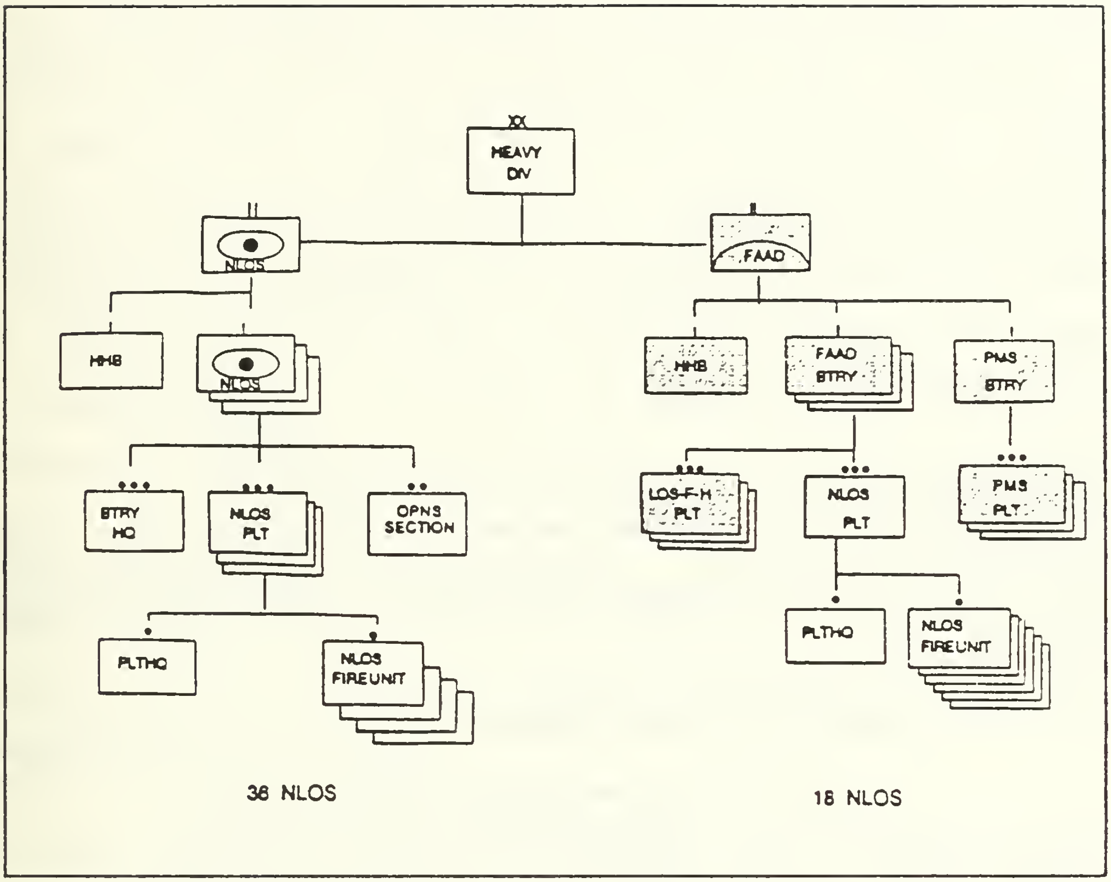

Figure 6. NLOS Organization

D. MISSIONS AND ROLES

1. NLOS-AT

a. *Mission*

The primary mission of NLOS-AT is "...massed ground targets beyond direct fire weapons range (Brigade Deep)." [Ref. 4:p. 2-2] Although NLOS-AT may be used in the direct fire mode if needed, the weapon will normally be reserved for the engagement of deep, high value targets.

b. NLOS-AT In The Ground Role

In the ground role, NLOS-AT will engage both preplanned targets and targets of opportunity. During the intelligence preparation of the battlefield process, enemy actions and movements will be predicted allowing the development of engagement areas. NLOS-AT gunners will preprogram missile routes into the engagement areas attempting to maximize damage to the enemy. As missiles fly to their intended targets, gunners may engage high priority targets (enemy command and control centers, for instance) encountered along the way. Additionally, NLOS-AT will respond to calls for fire on targets of opportunity as the battle unfolds. The call for fire procedure and linkage will be covered in detail in chapter three. NLOS-AT fire units will normally engage targets utilizing massed fires from two or more sections.

c. NLOS-AT In The Air Defense Role

Air defense is the secondary mission of NLOS-AT. NLOS-AT units will engage massed helicopters and single helicopter targets of opportunity. A typical scenario depicting the engagement of a helicopter target of opportunity would have the gunner spotting an enemy helicopter as his missiles are enroute to the target area. The gunner would immediately notify his platoon leader and divert the lead missile to engage the helicopter. The remaining missiles would procede to the preplanned target area. Engagement of massed helicopter formations may happen either as a result of air defense assets being overtaxed, or in response to the brigade commander's assessment that the air threat may be too great for air defense assets to counter alone. In the case where air defense assets are overtaxed, the AD platoon leader alerts the NLOS-AT battery of the need for assistance. The battery alerts the NLOS-AT platoon, and the fire sections are told to launch a prescribed number of missiles. The fire units are able to locate the massed raid either by coordinates provided by the AD platoon leader, or through use of the onboard sensor. In situations where the brigade commander anticipates an overwhelming air threat, a percentage of NLOS-AT missiles may be predesignated for the air defense role.

2. NLOS-AD

a. *Mission*

The primary mission of NLOS-AD is "...to defeat helicopters which cannot be engaged by other systems." [Ref. 4:p. 2-5] Since other air defense systems such as ADATS and STINGER are capable of engaging helicopters that are within line-of-sight, NLOS-AD should be reserved for masked rotary wing aircraft.

b. ***NLOS-AD In The Air Defense Role***

Due to the nature of the helicopter threat, effective NLOS-AD employment will be contingent upon the ability to locate and acquire targets early enough to ensure successful engagement. The detection of masked helicopters at the extended ranges necessary for successful NLOS engagement is a capability that pushes the sensor technological envelope. The development of masked target sensors (MTS) is a crucial element in the proposed Forward Area Air Defense Command, Control and Intelligence (FAADC2I) network. The NLOS-AD employment concept assumes the successful integration of MTS into the FAADC2I network. Currently, MTS efforts are in the modeling and simulation stages and no hardware has yet been fielded.

Covered in more detail in the next chapter, the FAADC2I network is comprised of various sensors and communications equipment which will not only enable NLOS-AD to acquire and engage helicopters, but will also help preclude simultaneous engagements by more than one AD system. During normal NLOS-AD operations the fire unit will receive target information from the FAADC2I network which will be displayed on the gunner's console. The gunner simply selects the target he intends to engage and launches a missile or missiles. The FAADC2I system sends continuous updates to the missile in flight, effectively guiding the missile to the target. The NLOS-AD gunner may also respond to calls for fire on targets that may not be visible on the gunner's console. In these situations he must rely on coordinates provided by the individual originating the call for fire, or assistance from the onboard seeker to, find the target.

c. NLOS-AD In The Ground Role

Engagement of ground targets is the secondary mission of NLOS-AD. NLOS-AD will be used in the ground role when no NLOS-AT forces are available, or enemy breakthrough is imminent. Once the brigade commander makes the decision to employ NLOS-AD in the ground role, the brigade fire support element notifies the AD platoon leader of the target location, description, and number of missiles to fire. The fire units enter the target location into the NLOS computer and launch the required missiles. NLOS-AD missiles in flight, enroute to ground targets should not be diverted to targets of opportunity because their use in the ground role is reserved for critical missions in the first place.

E. EMPLOYMENT ON THE BATTLEFIELD

Since NLOS-AT and NLOS-AD have distinctly different missions, their primary target areas will generally be split on the battlefield. NLOS-AD targets will most often be within 5 to 10 kilometers of the forward line of troops (FLOT) due to the fleeting nature of the attack helicopter threat. NLOS-AT targets will usually be deep targets in the enemy second echelon battalions and regiments (10 - 20 kilometers from the FLOT). Target areas may at times overlap due to the secondary missions of both systems, however the normal target area split is shown in Figure 7. The area depicted in Figure 7 is approximately 15 by 25 kilometers and is a typical battalion sector of operations. Viewing the figure from a temporal viewpoint NLOS-AD must be capable of engaging helicopters flying at speeds between 80 and 125 knots within 5 kilometers of the FLOT, while NLOS-AT must engage slow moving or stationary targets at extended ranges. It would seem that from a time perspective, the air defense and ground roles differ greatly. What the ramifications of this time difference are, in terms of command and control and fire planning, will be covered in the next chapter.

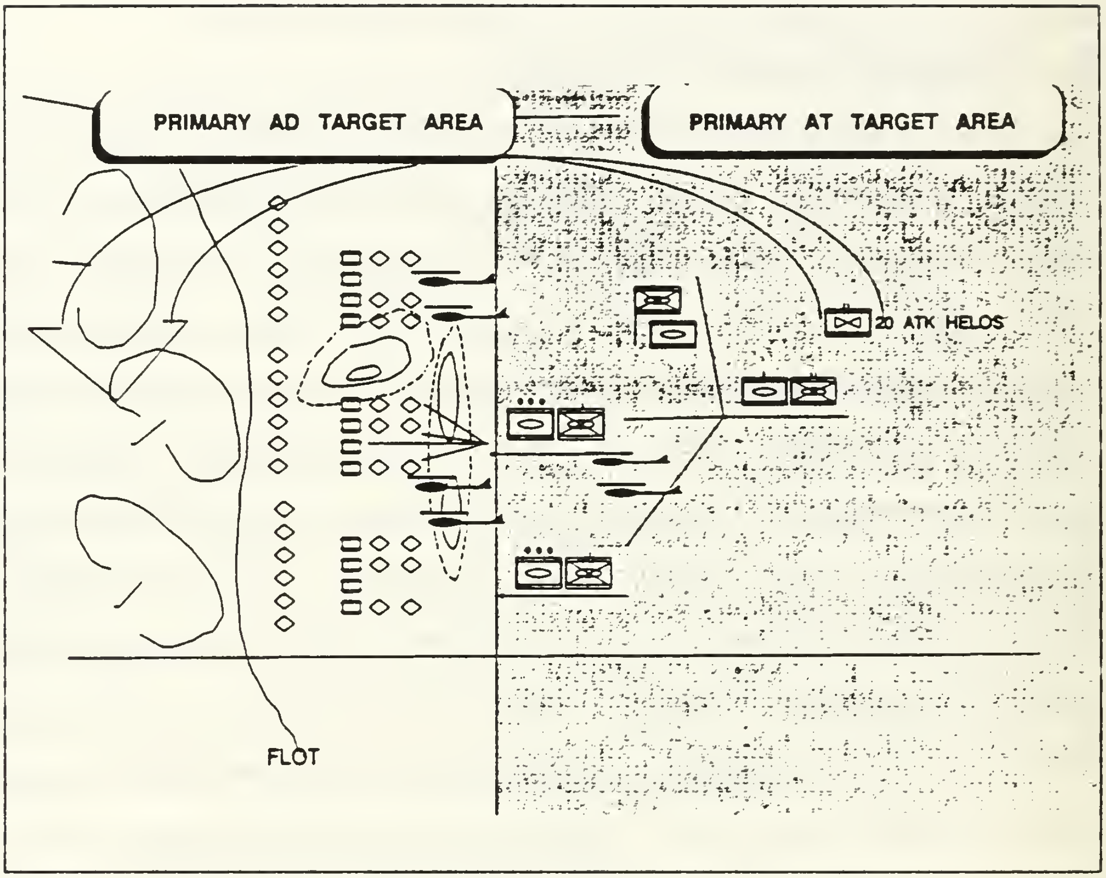

Figure 7. NLOS Divided Target Area [Ref. 4:p. 2-6]

III. COMMAND AND CONTROL

A. INTRODUCTION

A discussion of command and control for NLOS must begin first with a definition of command and control. The term "command and control" has come to mean many things to many different people:

> One of the least controversial things that can be said about command and control (C2) is that it is controversial, poorly understood, and subject to wildly different interpretations. The term can mean almost everything from military computers to the art of generalship: whatever the user wishes it to mean. [Ref. 5:p. 23]

Command and control is referred to today as C3 (command, control and communications), C3I (command, control, communications, and intelligence), or even C4 (command, control, communications, and computers). For simplicity and clarity, all references to command and control in this paper will be consistent with the Department of Defense (DOD) definition specified in Joint Chiefs of Staff Publication 1 (JCS Pub 1): "Command and control is the exercise of authority and direction by a properly designated commander over assigned forces in the accomplishment of the mission." [Ref. 6:p. 77] This definition, while seeming straightforward enough, still needs some clarification. The question of how the commander exercises authority and direction needs to be addressed. The commander utilizes both a command and control system and a command and control process to exercise authority and direction over his forces. The command and control system consists of: "The facilities, equipment, communications, procedures and personnel essential to a commander for planning, directing, and controlling operations of assigned forces pursuant to the missions assigned." [Ref. 6:p. 77] While the concept of command and control alluded to earlier has existed since the dawn of warfare, the command and control system is constantly changing to keep up with the pace of modern technology. The command and control process (see Boyd's O-O-D-A Loop, Figure 8) is one in which the commander observes the environment, orients himself to the information received, makes a decision, and acts upon that decision which, in turn, changes the environment, and the cycle starts again.

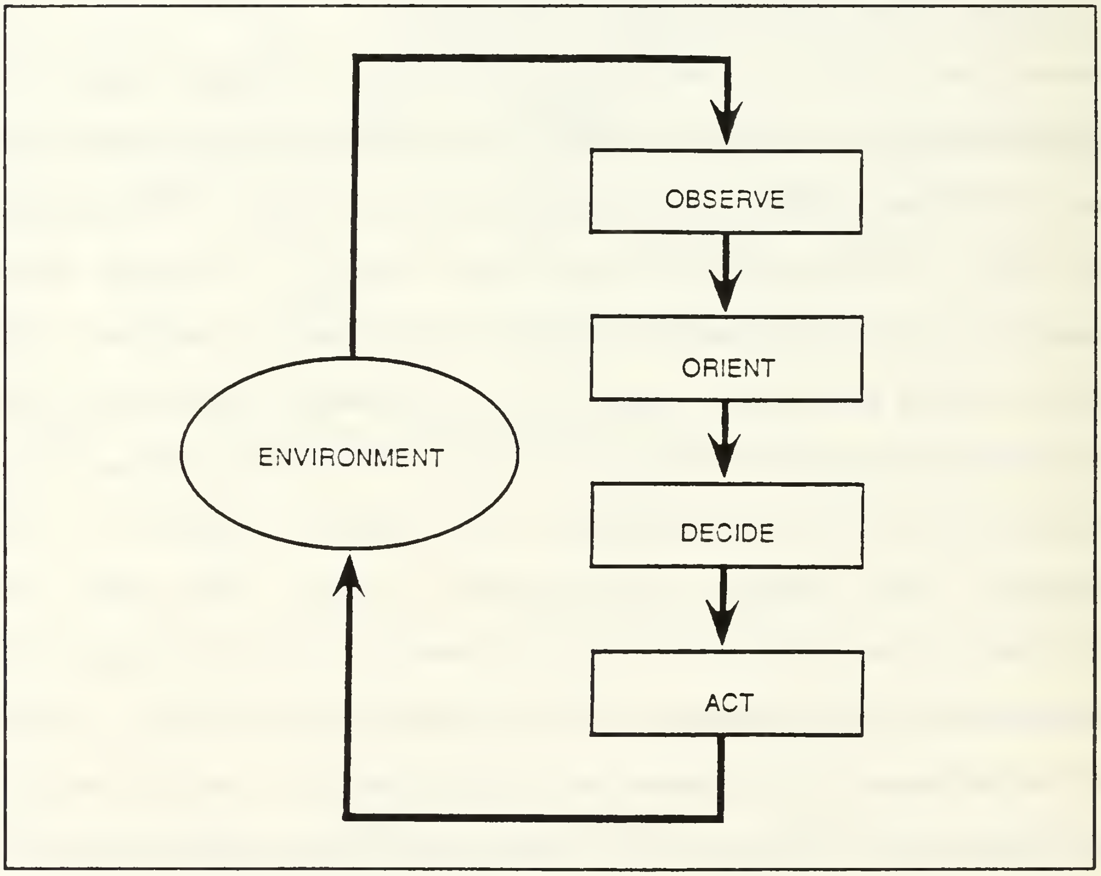

Figure 8. Boyd's O-O-D-A Loop

The very essence of the command and control process is how much time it takes the commander to step through the cycle relative to the time it takes the opposing commander to do the same. A quicker cycle time most often results in the slower commander having to counter moves by the quicker, instead of being proactive. This is one effect that allows superior command and control to be a combat multiplier on the battlefield.

The command and control process, as described by Boyd's O-O-D-A Loop above, is a process which remains unchanged, regardless of the nature of the mission or the level of command. Commanders at all levels observe the situation, orient themselves to new inputs, decide what needs to be done, and take actions based on those decisions. Air Defense commanders, Field Artillery commanders, Infantry commanders, and Armor commanders all step through this process in some form or another even though the forces they command, and the weapon systems they employ, may be distincly different. This is not the case with command and control systems. The "facilities, equipment, communications, procedures and personnel" that the commander utilizes in stepping through the command and control process is, more often than not, tailored to specific mission requirements and weapons characteristics. In fact, because NLOS is to be utilized in both the air defense and ground roles, two distinct command and control systems have been proposed, one for each role. Section B will discuss the command and control system for NLOS-AD and section C will discuss the NLOS-AT command and control system. The concept for tying both systems together at the brigade TOC will be presented in section D, "NLOS-CA Command and Control."

B. NLOS-AD COMMAND AND CONTROL

1. General

Air defense command and control is based on three fundamental principles: centralized management with maximum decentralized authority to engage; air battle management; and management by exception [Ref. 7:p. 5-2]. Centralized management provides for coordination and integration of the air defense force as a whole, and ensures all AD operations support the maneuver commander's intent and concept of the operation. The decentralization of authority to engage is made necessary by the nature of the air threat. The individual with his finger on the trigger of the air defense weapon must be given the authority to engage if the response to the air threat is to be rapid and flexible enough. Air battle management refers not only to ground-based air defense resources, but also to tactical air assets. The coordination of air and ground units is essential to prevent mutual engagement of the same targets, and to preclude engagement of friendly aircraft. Air battle management is accomplished utilizing two methods of control:

1. Positive control is the use of real time data from radar, IFF [Identification Friend or Foe], computer, digital data link, and communications equipment to fight the air battle [Ref. 7:p. 5-2].

2. Procedural control manages the air battle dividing up the airspace by volume and time, and by use of weapons control statuses.

Due to the unpredictable nature of the air battle, situations which were not addressed by positive or procedural control measures will inevitably arise. Management by exception is excercised in these situations where, on a case by case basis, higher headquarters intervenes to provide direction. The command and control system for NLOS-AD must provide the means by which these fundamental principles are embodied. The discussion of NLOS-AD command and control in this chapter is more generic in nature than will be that of NLOS-AT. This is because the Red Paper did not discuss an NLOS-AD command and control concept that was distinct from that which is utilized for other air defense systems. The discussion provides the reader with a basic understanding of air defense command and control planning. It begins with a description of the standard AD tactical missions. AD planning principles and guidlines are then covered. Specific procedures used for air battle management are then detailed, and the facilities, equipment, personnel, and communications are introduced in a narrative describing both the FAADC2I system and the Manual Short Range Air Defense Command and Control System (MSCCS).

2. AD Standard Tactical Missions

a. *General Support (GS)*

An air defense unit with a general support mission supports the maneuver force as a whole. Fires are not dedicated to any specific unit of the force.

b. *General Support-Reinforcing (GS-R)*

An air defense unit with a general support-reinforcing mission supports the force as a whole, and reinforces the fires of another air defense unit. Fires are not dedicated to any specific unit of the force.

c. *Reinforcing (R)*

An air defense unit with a reinforcing mission augments the fires of another air defense unit which is committed to a specific element of the supported force. Both the reinforcing AD unit and the reinforced AD unit are committed to specific elements of the force.

d. *Direct Support (DS)*

An air defense unit with a direct support mission provides dedicated air defense coverage to a specific unit of the supported force. AD units are assigned direct support missions to units which have no organic or assigned AD assets.

3. Air Defense Planning

a. *Development of Air Defense Priorities*

(1) General. During the planning phase, the AD commander is briefed on the maneuver commander's intent, his concept of the operation, and critical assets needing air defense coverage. He then evaluates each asset in terms of criticality, vulnerability, recuperability, and threat, to establish priorities for air defense.

(2) Criticality. Criticality is a measure of the degree to which a particular asset is essential to accomplishment of the mission. Assets are prioritized in terms of the potential consequences of their destruction or damage, as those which:

- Are capable of preventing the execution of a plan of action.
- Will cause immediate and serious interference with the execution of the plan of action.
- Can ultimately cause serious interference with the execution of the plan of action.
- Might cause limited interference with execution of the plan of action. [Ref. 7:p. 4-7]

(3) Vulnerability. Vulnerability is is a measure of the asset's ability to survive on the modern battlefield. The factors which should be considered when assessing vulnerability are the asset's mobility, hardness, and role in the overall mission.

(4) Recuperability. Recuperability is a measure of the degree to which, and how quickly, the asset can be put back into normal operation, once damaged.

(5) Threat. Each asset is evaluated in terms of how valuable it is perceived to be by the enemy. Enemy doctrine and past actions are examined to determine what assets will be of high value for targeting purposes. The assets are then prioritized in terms of their likely probability of attack.

b. Planning Principles and Guidelines

(1) General. After the AD priorities are approved by the maneuver commander, the AD commander then plans how to best defend the critical assets. Air defense planning embodies a number of principles and guidelines which serve to ensure that the limited air defense resources on the battlefield are used to maximum advantage. It is particularly crucial that air defense commanders encorporate the AD principles and guidelines in the planning phase of operations, because it is during the planning phase where the "centralized management" function is implemented. If the AD commander fails to provide the proper direction to AD forces early in the planning phase, actions in the decentralized execution phase, most probably will not be focused to provide optimum air defense support.

(2) Principles. The air defense principles of mass, mix, mobility and integration provide the doctrinal bedrock on which all air defense design is built. Although each tactical situation may be unique, the tailoring of the above principles to fit the mission at hand will result in optimum employment of NLOS-AD, as well as all other air defense weapons on the battlefield. An explanation of the principles, as detailed in FM 44-1, U.S. Army Air Defense Artillery Employment, is provided below:

> Mass is the concentration of ADA combat power achieved by allocating sufficient fire units to successfully defend the asset against attack. For SHORAD [Short Range Air Defense] systems, mass is normally not achieved with units smaller than platoon size. However, in many instances, only a platoon of SHORAD weapons may be allocated to defend battalion-size maneuver units and associated static assets. A unit smaller than a platoon should not normally be assigned an AD mission with the exeception of MANPAD [Man-Portable Air Defense] sections. In the case of HIMAD [High to Medium Air Defense] weapons, a battalion-size element is the smallest unit capable of achieving mass. Only in rare circumstances would an asset be defended with a HIMAD element smaller than a battalion.
>
> Mix is a balance between AD aircraft and ADA systems, or between specific types of ADA systems, that offsets the limitations of one with the capabilities of the other. Mix forces the enemy to defend his air forces against an array of systems rather than against a single system. Defeating such an array of air defense weapons, each with different characteristics and capabilities, is extremely difficult and greatly complicates Threat strategy.
>
> Mobility is the capability of AD forces which permits them to move from place to place while retaining the ability to fullfill their primary mission. ADA units tasked with providing air defense to maneuver units should possess mobility equal to that of the supported element. ADA units defending static assets must be capable of rapid displacement to alternate and secondary positions as well. ADA units operating in a high intensity environment must rely heavily upon mobility for survival as well as upon their air defense capability.
>
> Integration is the close coordination of effort and unity of action that maximizes individual AD system operational effectiveness while minimizing mutual interference among operating forces. Integration is vital to all operations on the AirLand Battlefield. ADA weapons must be fully integrated into the force commander's scheme of maneuver and into the battle for air superiority as well. Massed, mixed, and mobile ADA weapons are integral parts of both the supported force

commander's operation and the higher echelon ADA operation and must be responsive to both. Integration necessitates effective command and control links capable of sustained operations in a high intensity NBC [Nuclear Biological Chemical] and EW [Electronic Warfare] environment. [Ref. 7:pp. 4-11 - 4-12]

The application of these principles as they apply to NLOS-AD, will be similar to other SHORAD systems in that the principles of mass and mix will be more suited to defensive operations and the principles of mobility will more readily apply to offensive operations.

(3) *Guidelines*. The air defense planning guidelines serve to further define the desirable characteristics of a well planned defense of a critical asset. NLOS-AD planning will necessarily make extensive use of some of these guidelines more than others, due to the weapon system's capability to deliver precision guided munitions. The guidelines are listed below:

- Balanced fires are achieved when air defense weapons are spread around the defended asset in an equitable manner, thereby providing equal fires in every direction.
- Weighted coverage is made possible by positioning air defense weapons along expected enemy air avenues of approach.
- Mutual support is achieved when adjacent air defense units are positioned in such a manner as to allow one unit to fire into the dead zones of the other. In the case of mutual support, the dead zones are more of a result of weapon system characteristics than of positioning.
- Overlapping fires occurs as a result of adjacent fire units being positioned such that their engagement envelopes overlap.
- Early engagement ensures that attacking aircraft are engaged before they reach their anticipated ordnance release point.
- Defense in depth is achieved when air defense weapon systems are positioned in a manner to guarantee that hostile aircraft encounter increasing volumes of fire as they close on a defended asset.

NLOS-AD is ideally suited for mutual support applications because of its capability to engage masked targets. Air defense early engagement will be enhanced because of the extended range of NLOS. When NLOS-AD is utilized in the defense in depth context, the gunner's capability to steer the missile at the target will greatly enhance final protective fires for the asset.

4. Air Defense Procedures

a. *General*

The decentralized execution of the air defense mission dictates that procedural methods of control be established to enable higher level air defense commanders to define the limits within which engagement is authorized. Outside of these prescribed limits, engagements should not occur, except in self defense.

b. *Air Defense Warnings (ADW)*

Air defense warnings are used to give subordinate units the commander's appraisal of the probability of an air attack occuring. In this context, the commander refers to the regional air defense commander. Local commander's may declare ADW's for their areas of operations based on enemy activity. The ADW'S are listed below:

- ADW RED means that an air attack is imminent or in progress.
- ADW YELLOW means that an air attack is probable.
- ADW WHITE means that an air attack is not probable.

c. *Rules of Engagement*

(1) General. Rules of engagement are promulgated to delineate the specific circumstances under which aircraft may be engaged. They exist, in part, to provide a modicum of centralized control over air defense engagements, but also to preclude fratricide. In addition to the universal

right of self defense, rules of engagement include hostile criteria and weapons control statuses.

(2) *Hostile Criteria*. Hostile criteria generally includes, but is not limited to, aircraft that:

- Attack friendly forces or installations
- Conduct minelaying in territorial waters
- Violate airspace control measures
- Are visually identified as hostile

Other actions like the dropping of paratroopers or the discharging of smoke or spray may be added, depending on the tactical situation.

(3) *Weapons Control Statuses (WCS)*. Weapons control statuses dictate relative degrees of freedom to fire for air defense weapon systems. More restrictive WCS's tend to minimize fratricide, but also give enemy aircraft a higher probability of survival. The converse is true of less restrictive WCS's. The air defense WCS's are:

- Weapons Free - Fire at any aircraft not positively identified as friendly. This is the least restrictive case.
- Weapons Tight - Fire only at aircraft positively identified as hostile.
- Weapons Hold - Fire only in self defense or in response to an order from higher authority. This is the most restrictive case.

d. *Airspace Control Measures*

Air space control measures, as mentioned earlier, are supplemental fire control measures which facilitate air battle management. The area above the battlefield is divided vertically and horizontally into volumes of airspace in which friendly aircraft are permitted to fly. Some relatively common airspace control measures are listed below:

- Weapon engagement zones (WEZ) identify volumes of airspace that have been established for the engagement of aircraft by a specific AD weapon system.

- High density airspace control zones (HIDACZ) are volumes of airspace in which a heavy concentration of numerous and varied users is expected.

- Low level transit routes (LLTR) are temporary corridors of defined dimensions that allow high-speed aircraft to transit the tactical operations area at low altitudes.

When no positive control measures (IFF etc.) are available, these procedural measures may be the only method, short of visual identification, to separate friend from foe during the airbattle.

The facilities, equipment, personnel, and communications of the command and contol system must support the utilization of the above procedures. Facilities include mobile shelters and associated equipment that make up tactical operations centers and command posts. Equipment includes sensors, input/output devices, software, and processors. The personnel are the commanders and their supporting staffs, and the communications are provided by transmitters and receivers of all types. The FAADC2I system is the proposed solution for NLOS-AD in terms of the above elements of the command and control system. Although the FAADC2I system will provide an automated digital capability, and integrate numerous sensors and weapon systems, the current manual system will serve as a back up.

e. *The (MSCCS) System*

The command and control system currently in place in the SHORAD battalions of the U.S. Army is called the Manual SHORAD Command and Control System (MSCCS). The system is a collection of sensors tied together via FM (Frequency Modulated) radios with the battalion TOC, Air

Battle Management Operations Center (ABMOC), and AD command posts down to platoon level. The SHORAD battalion has eight sensors called Forward Area Alerting Radars (FAAR). These pulse doppler radars have a range of twenty kilometers, and are used to provide early warning both to AD units and to the rest of the force as a whole. FAAR operators detect targets on their scopes and manually plot the location on a reference grid which all the AD fire units have as well. They then transmit voice messages containing target location and tentative identification to all units within FM radio range (thirty-five kilometers, line-of-sight). The transmission is also received at the ABMOC, which is the SHORAD battalion's processor of information used to fight the air battle. The ABMOC plots the targets received from all the battalion's FAARS, and rebroadcasts the target information to the division on the division early warning net (DEW). The DEW is a network of FM radios that offers redundant communications throughout the division area of operations for the purpose of providing advanced notice of air attack.

The time between FAAR target detection and arrival of the target in the area of operations is often measured in seconds. NLOS-AD needs much more time than this to effectively engage targets. Additionally, NLOS-AD needs to be provided with the locations of targets not within line-of-sight. The FAAR radar does not have this capability. It is fortunate that the manual system described above will only be used in a back up role in the future. NLOS-AD, like all other members of the FAADS family of air defense weapons will receive real time target updates from the FAADC2I network.

f. *The FAADC2I System*

The proposed FAADC2I system will acquire information from various sensors. The sensors will include not only those sensors organic to AD units, but also those managed by other battlefield functional areas, such as electronic warfare (EW) and fire support. A specific enhancement which will benefit NLOS-AD is the integration of aerial sensors such as the unmanned aerial vehicle (UAV). The look down capability of the UAV will provide non-line-of-sight early warning and cueing for NLOS-AD. All air defense systems (HIMAD and SHORAD) will be integrated into a Joint Tactical Information Distribution System (JTIDS) which will share real time digital data obtained from the myriad of sensors with all users. The division Army Airborne Command and Control (A2C2) Element, which coordinates the use of all friendly airspace, will also be integrated into the JTIDS net. This should serve to reduce fratricide of Army Aviation elements and enhance air battle management. Aircraft identification will be enhanced by the improved ability to share IFF data via the JTIDS link and technological improvements in target recognition. In addition to the RF (Radio Frequency) transponders now in use, Non-Cooperative Target Recognition (NCTR) concepts such as imaging radar (IR) and electro optics will be incorporated into the FAADC2I network. Target correlation will be greatly improved through the integration of the Enhanced Position Location Reporting System (EPLRS), because all units with a tie into the ADA EPLRS will have the same geographical frame of reference. The conceptual FAADC2I system is depicted in Figure 9. Although some testing has been conducted on surrogates of the proposed system it is still largely in the developmental stages. Force Development

Test and Experimentation I (FDTE I) is currently scheduled for November 1991.

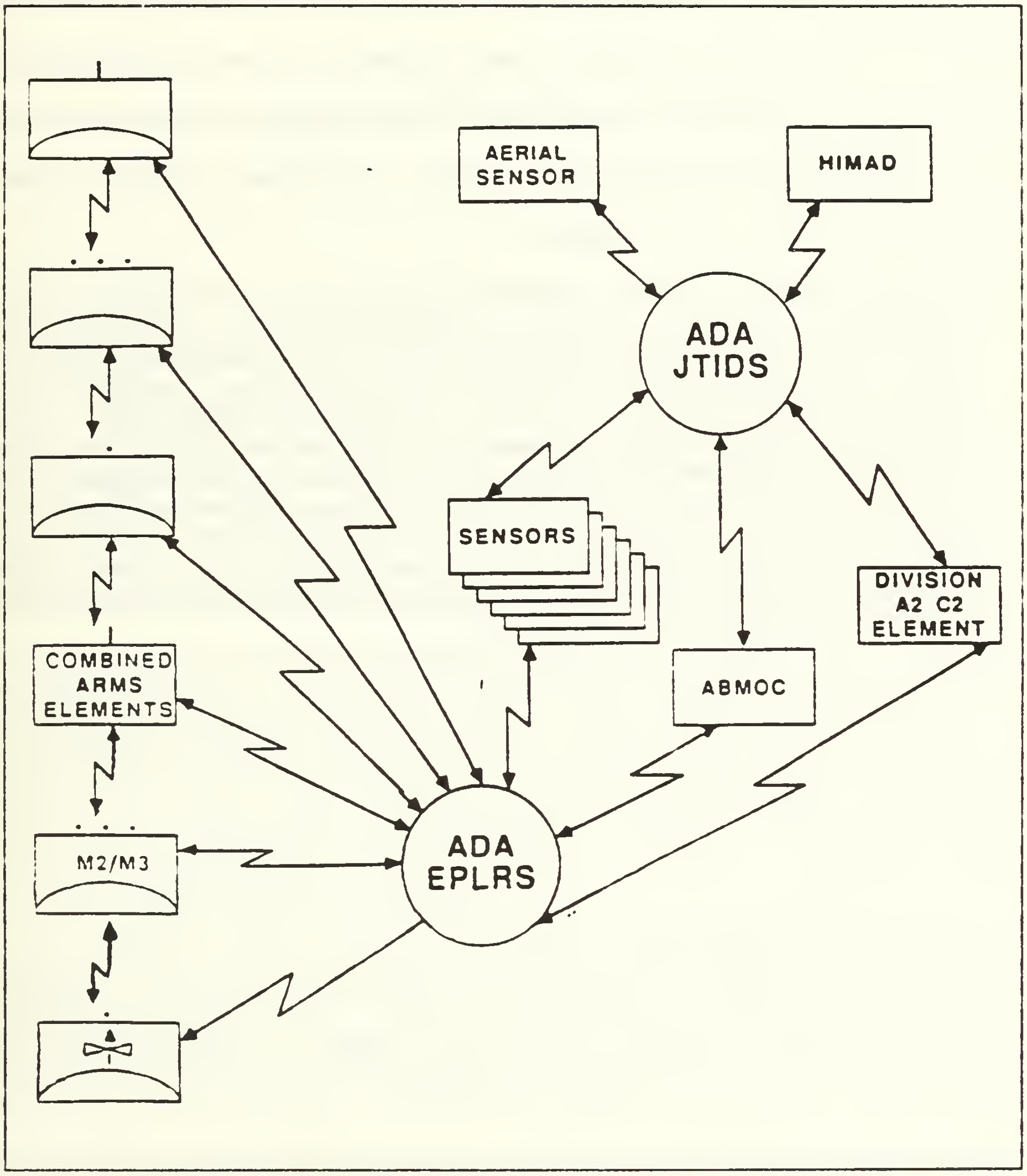

Figure 9. The Conceptual FAADC2I System [Ref. 1:p. 3-3]

C. NLOS-AT Command and Control

1. General

The NLOS-AT employment concept as detailed in the NLOS-Combined Arms (CA) Tactics, Techniques and Procedures (TTP) manual dictates that NLOS-AT is fought as a field artillery weapon. As such, maximum feasible centralized control is the underlying principle which characterizes command and control of NLOS in the ground role. In certain situations, however, decentralization may be preferred:

> FA is most effective when control is centralized at the highest level consistent with its fire support capabilities and the requirements for the overall mission. Centralized control of FA permits flexibility in its employment and ensures that effective support can be rendered to each subordinate element of the command and to the force as a whole. Each standard tactical mission represents a different degree of centralized control and a different degree of responsiveness to the committed units. Control of the FA with a force must be decentralized sufficiently to make some FA immediately responsive to the needs of the committed units, but some FA normally is kept responsive to the needs of the force as a whole. The optimum degree of centralized control varies with each tactical situation. [Ref. 8:p. 107]

Unlike the situation involving NLOS-AD, where the decision to decentralize is based on the inherent reactive nature of all air defense engagements, the decision to decentralize NLOS-AT, is based on the nature of the specific tactical situation. In general a high degree of centralized control is desired for defensive operations, while FA units in the offense are more decentralized. NLOS-AT, because of its ability to engage deep, high value, targets, however, will almost always be fought in the centralized mode. According to the NLOS-CA TTP, "All decisions to fire NLOS-AT will be made by the Bde FSE based on the Bde Commander's guidance in the planning stage or as the target presents itself." [Ref. 4:p. 2-4] Since such positive control over NLOS-AT fires is planned, the need for elaborate procedures aimed at providing guidance to the NLOS-AT units is not required as it is with NLOS-AD. NLOS-AT procedures and planning center around the development of engagement areas based on intelligence preparation of the battle. The FA standard tactical missions of Reinforcing, General Support, General Support-Reinforcing, and Direct Support are identical to those for air defense. The discussion of the NLOS-AT command and control system which follows will first cover fire planning and then outline the facilities, equipment, personnel, and communications required for successful command and control of the NLOS-AT weapon system.

2. NLOS-AT Fire Planning

Fire support planning for the brigade is done by the fire support officer (FSO), a member of the supporting FA unit. The supporting FA battalion commander is the brigade commander's fire support coordinator (FSCOORD) and the FSO is his representative at the brigade TOC. The FSO heads the fire support element (FSE), which plans, coordinates, and integrates NLOS-AT fires with other fire support weapon systems. According to the NLOS-AT TTP, NLOS fires are a valuable commodity to be used wisely to produce the most favorable results:

> Because of the unique NLOS capabilities and the limited number of missiles, the FSE should plan fires with the intention of making significant things happen. NLOS missiles are too expensive and too limited in number to waste on other than high payoff targets. Therefore fires must be well planned and well coordinated. [Ref. 4:p. 4-1]

The planning process begins with a a thorough intelligence preparation of the battlefield in which the brigade intelligence (S2) officer identifies likely enemy avenues of approach into the brigade sector. Using doctrinal templates, predicted locations for second echelon battalions and regiments are plotted. Also, possible regimental artillery groups (RAG), division artillery groups (DAG), enemy command and control nodes are predicted as potential target locations. The FSE then selects which targets to be engaged by which weapon systems based on the commander's guidance and the factors of METT-T. Engagement areas are then established through coordination by the FSO with the brigade S2 and the brigade operations officer (S3). Engagement areas are assigned to specific weapon systems and promulgated in the fire support plan. When the fire plan is received from brigade, the NLOS-AT battery plans platoon positions, movement plans, and allocates missiles for the assigned engagement areas. Trigger points are assigned for engagement areas by the battery operations officer. Trigger points are locations where the intended target's arrival keys execution of the engagement sequence. Once the trigger points are established and engagement areas are assigned to platoons, the battery provides this information to the NLOS-AT LNO at the brigade TOC. Sensors are assigned by brigade to monitor the trigger points. As targets arrive at the trigger points the sensor cells direct the fire units to fire. (The communication nets which support this concept will be covered below). Engagement of targets of opportunity requires the use of a target prediction procedure. This procedure is employed in the battery TOC and the result is the predicted location of the target subsequent to the flight of the missile. The fire units receive the predicted location, and launch their missiles accordingly.

3. NLOS-AT Command and Control System

The NLOS-AT command and control system is comprised of a number of sensors tied together with command posts and fire units primarily by FM radio. Although future plans call for NLOS-AT to have access to the digital data provided by the field artillery's tactical fire direction system (TACFIRE) and/or its replacement, the advanced field artillery tactical data system (AFATDS), the NLOS-AT command and control system is at present, a manual system.

Some of the sensors that are used to cue NLOS-AT to ground targets are:

- UAV
- OH-58D Helicopter
- NLOS video (played back from previous missions)
- Forward Observers
- Combat Observation and Lasing Team (COLT)
- Military Intelligence Sources such as the ground surveillance radar
- Other Sources (JSTARS from Division, FAAD system)

Although some of the sensor data is sent directly to fire units and battery's over quickfire channels, the sensor data is normally collected at the the brigade TOC. The sensor data is distributed to the NLOS-AT units throughout the brigade on four different FM radio nets:

- The brigade fire support coordination net
- The NLOS-AT fire direction net
- The NLOS-AT battery command net
- The NLOS-AT platoon net

The four radio nets and their users are depicted below in Figure 10, a matrix extracted form the NLOS Concept Evaluation Program (CEP) report. The brigade fire support element monitors the brigade fire support coordination net and the NLOS-AT fire direction net. The NLOS-AT battery operations center monitors the brigade fire support coordination net, the NLOS-AT fire direction net, and its own battery command net. The NLOS-AT platoon monitors the NLOS-AT fire direction net, the NLOS-AT battery command net, and its own platoon net provides communications with the individual fire units. The fire units monitor only the NLOS-AT platoon net.

RADIO NETS	BDE FSE	NLOS BTRY TOC	NLOS PLT	LAUNCHER
BDE FS COORD	■	■		
NLOS FD	■	■	■	
BTRY CMD		■	■	
PLATOON			■	■

Figure 10. NLOS-AT Radio Nets

D. NLOS-CA COMMAND AND CONTROL

The focal point for NLOS operations in the brigade is the brigade fire support element (FSE). The brigade commander relates his intent and approves the air defense and fire support priorities, but synchronizing the NLOS fight during the battle is accomplished by the FSE. Decisions to engage with NLOS-AD are made at the fire unit level, but the FSE makes the decision to engage ground targets with either NLOS-AT or NLOS-AD. Once the decision is made, either the NLOS-AT LNO or the NLOS-AD platoon leader informs the appropriate fire units. The NLOS Concept Evaluation Plan (CEP) report portrayed this process as depicted in Figure 11. Notice that while all ground targets are sent to both NLOS-AT and AD units, the air targets stay in AD channels. This is because, as mentioned earlier, NLOS-AT will engage air targets only as they are encountered enroute to preassigned ground targets, or when AD fire units are overtaxed.

The establishment of the doctrinal employment and the command and control scheme for weapon systems not yet in the field is a highly evolutionary process. Subject matter experts who have experience with similar weapons are called on to envision how the new technology should be used. Once the fundamentals have been "envisioned," testing is conducted to determine whether the doctrine makes sense or not. The earlier in the evolutionary process a weapon system is, the harder it is to test crucial issues. NLOS will not undergo FDTE until October 1991. The actual system and much of the command and control technology proposed for it, is not yet available. This poses severe limitations on testing. In the next chapter testing conducted by the Army as part of the NLOS CEP will be described.

The question of whether or not NLOS can be commanded and controlled in the dual role will be examined in the light of test findings.

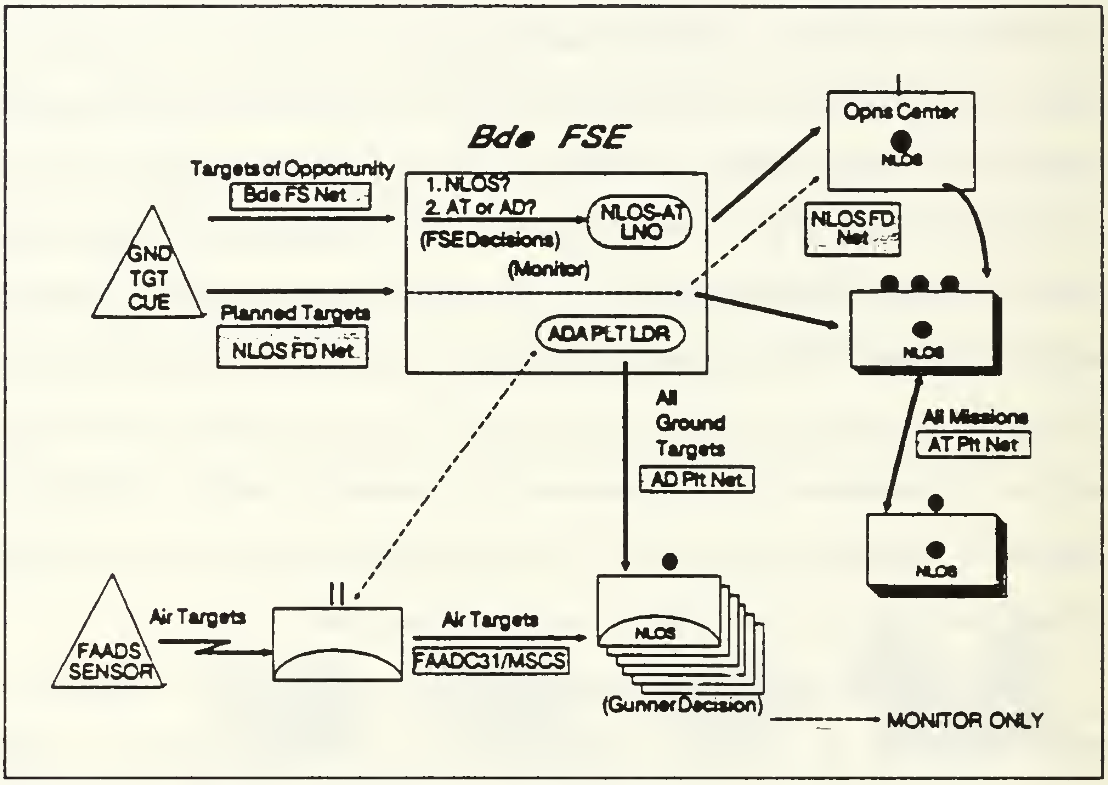

Figure 11. NLOS-CA Command and Control

IV. NLOS COMMAND AND CONTROL TESTING

A. INTRODUCTION

The NLOS Concept Evaluation Plan (CEP) was commissioned by the TRADOC Deputy Chief of Staff for Combat Developments (DCSCD) to "...investigate the command and control implications of NLOS and the anti-tank role." [Ref. 9:p. 1-1] Department of the Army Pamphlet 71-3 defines a CEP as follows:

> The CEP is a specifically funded innovative testing program. It is available to commanders and the CBTDEV [Combat Developers] to provide a quick reaction and simplified process to resolve combat development, doctrinal, and training issues. [Ref. 10:p. 1-8]

The investigation conducted by the CEP explored many issues and questions, and consisted of many tests and simulations, but one test in particular, the Battle Control Cell Test (BCCT), was considered to be the most significant. The purpose of the BCCT was to "...evaluate the tactical command and control procedures necessary to employ the non-line-of-sight (NLOS) weapon system at the maneuver brigade level." [Ref. 11:p. 1-1] The NLOS-CA Tactics, Techniques and Procedures manual was used as the primary reference for the test, which was conducted at Fort Hood Texas during the period 19 through 22 September 1989.

B. THE BATTLE CONTROL CELL TEST

1. Test Description

a. *Tactical Context*

The BCCT was conducted in two phases utilizing the Army Training Battle Simulation System (ARTBASS). ARTBASS provided computer-driven tactical scenarios which allowed player personnel to interact with the threat and with each other on a real-time basis to effect battle outcomes. Phase I simulated a brigade in the defense against three attacking enemy regiments in a central European environment. Phase II, also in a central European environment, portrayed brigade offensive operations against weakened regimental forces in hasty defensive positions. Both phases provided approximate 3 to 1 ratios of attacker versus defender. The task organization for the test mirrored the employment outlined in the NLOS-CA Tactics, Techniques, and Procedures (TTP) manual and is shown in Figure 12. (next page)

b. *Test Limitations*

As mentioned earlier, the testing of new systems poses many problems. Most of the test limitations are a direct result of the weapon system's early stage of development. Taken directly from the actual test report, the test limitations were as follows:

> Since the NLOS weapon system is still being developed, the actual system hardware was not available for the BCC test. The Army Training Battle Simulation System (ARTBASS) used during the test could not portray the characteristics of the future Army sensors or the NLOS weapon system fire units. Thus, times could only be measured from the time a sensed target cue entered the tactical operations center (TOC) until the platoon operations center (POC) sent the command to fire to the launcher control station. [Ref. 11:p. 1-2]

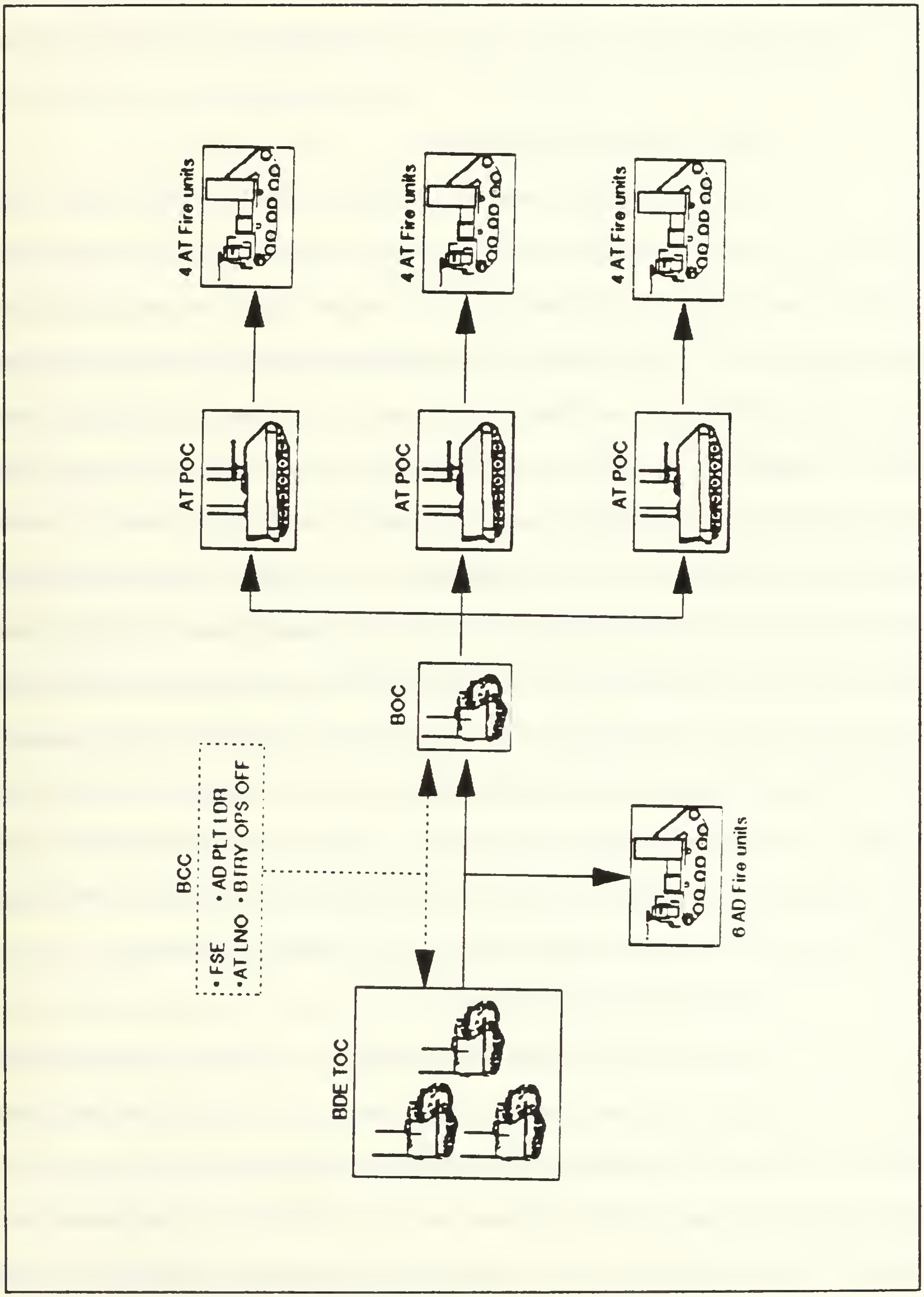

Figure 12. BCCT Task Organization

Even though these limitations are considerable, the use of ARTBASS provided an environment in which some useful observations concerning the ability of the BCC to command and control NLOS could be made.

c. *The Player Test Stations*

The entity referred to as the battle control cell (BCC), portrayed conceptually with dotted lines in Figure 12, was comprised of players from two different locations. The brigade FSE, the NLOS-AD platoon leader, and the AT LNO were located in the brigade TOC, and the AT battery operations officer was located in the NLOS-AT battery operations center (BOC). In addition to those mentioned above, the brigade TOC consisted of an intelligence (S2) section and an operations (S3) section. The BOC conducted NLOS-AT mission planning and controlled the movement and resupply of the NLOS-AT platoons. The platoon operation centers (POC) each had an NLOS-AT platoon leader who positioned the fire units, controlled their fires, and reported their status to the BOC. Data collectors were placed in each player station to record the beginning and ending times for all NLOS missions. Communications between the cells was accomplished by the establishment of the four FM radio nets oulined in the NLOS-CA TTP manual and a hard-wired printer was located in the brigade S2 section.

d. *ARTBASS Control Stations*

(1) The Launcher Control Station. The NLOS-AD and NLOS-AT fire units were represented by a launcher control station. The purpose of the launcher control station was to simulate movement, resupply and firing of 12 NLOS-AT and 6 NLOS-AD fire units. (Recall that the division has 36 NLOS-AT and 18 NLOS-AD fire units so the above represents an actual

brigade slice of the division's NLOS assets.) Additionally, the launcher control station simulated launcher outages. The launcher station was manned by ARTBASS test team personnel.

(2) The Sensors Station. The ARTBASS sensors station was used to provide military intelligence sensor inputs from unmanned aerial vehicle (UAV) flights, and from Joint Surveillance Target Acquisition Reporting System (JSTARS) missions to the brigade TOC. The sensor station was manned by a military intelligence (MI) subject matter expert (SME) and an ARTBASS facilitator. To surrogate the UAV, an ARTBASS-generated OH-58D equipped with an infrared camera was flown at an altitude of 1500 meters. The surrogate was flown by the SME according to the sensor plan developed by the brigade S2. Targets within seven kilometers of the surrogate UAV were considered to be detected, and these sightings were sent to the hard-wired printer located in the brigade S2 section. A data collector recorded the time the sighting was received in the TOC and the time it took the S2 section to analyze the printout. The information was then forwarded to the S3 section for action or information. JSTARS information was provided on enemy formations in the brigade area. The MI SME allocated portions of time when JSTARS would be available in the brigade sector and during these times all enemy formations in the brigade sector were reported to the brigade S2 via voice message. The time of receipt, and processing time were recorded in the same manner as with the UAV sightings.

(3) The Maneuver Station. The function of the two ARTBASS battalion maneuver stations was to notify the brigade TOC of all enemy sightings by the maneuver forces. Enemy sightings were reported to the S3

section via voice message and times of receipt and processing times were recorded by the data collectors. The targets were processed as either NLOS or artillery fire missions. All NLOS targets were assigned numbers by the brigade FSE so that data collectors could track actions and times on a specific target after it left the TOC. A combat observation and lasing team (COLT) was stationed at one of the maneuver stations to cue NLOS-AT platoons directly. The primary purpose of the COLT team was to surveil trigger points and key fires into engagement areas, but NLOS targets of opportunity were also reported. Both the NLOS BOC and the brigade TOC monitored these transmissions on the NLOS fire direction net. The maneuver stations were manned by SME's.

(4) *The Fire Control Station*. The ARTBASS fire control station kept the brigade FSE updated on all friendly artillery movements and actions. Additionally, the fire control station reported all information received from counterfire radars to the TOC for target processing. All associated times for NLOS mission processing were recorded by the data collectors in the TOC. The brigade fire support officer (FSO) also requested close air support through the fire control station. Reconnaissance aircraft provided target cueing directly to the printer in the brigade S2 section. These targets were forwarded to the S3 section which decided to engage with field artillery or NLOS assets. SME's manned the fire control station.

(5) *The Air Defense Station*. The ARTBASS AD station was used to perform the FAADC2I mission. An AD SME detected helicopters by observing an ARTBASS monitor. He reported all sightings of enemy helicopters directly to the launcher control station. The NLOS-AD platoon

leader was not involved in the engagement process. This concept is consistent with the decentralized engagement concept outlined in the NLOS-CA TTP manual. The AD SME only notified the NLOS-AD platoon leader of a target if no AD launchers were available to fire the mission. The possibility of an NLOS-AT unit engaging the helicopter could then be explored in the TOC. The AD launcher controller did, however, notify the platoon leader of all engagements and missiles fired subsequent to the actual engagements. No mission processing times were recorded for AD engagements because no elements of the BCC were involved in the AD engagement process.

(6) The Enemy Control Station. The ARTBASS enemy control station was manned by an ARTBASS operator who fought the enemy forces in such a manner as to attain enemy offensive and defensive objectives.

e. *Data Collection*

Data collectors recorded all observations of test events on data collection forms. In particular, all NLOS mission processing times were recorded at the following stations: S2, S3, FSE, NLOS-AD platoon leader. AT LNO, BOC, and POC. Processing time began when the TOC was cued and ended when either when the target was first passed to the launchers, or when the mission was cancelled. Digital clocks at each test station ensured that times were synchronized throughout the test. Time was recorded to the nearest second. In addition to the above data collection efforts, test players and SME's provided subjective comments concerning the test and the NLOS-CA TTP manual after both the defensive and offensive phases.

f. *Engagement Area Planning*

During the planning phase, the brigade TOC identified fifty engagement areas for use during the test. Thirty-three were planned for use in the defensive phase and seventeen were planned for the offense. Trigger points were established by the BOC for each engagement area, in accordance with the NLOS-CA TTP manual. All engagements utilizing the preplanned engagement areas during the test were referred to as "engagement area planned missions." All other engagements were referred to as targets of opportunity. For engagement area planned missions combat observation and lasing teams (COLTS) were positioned at trigger points to enable them to initiate the firing into engagement areas. Mission processing times were thus measured from the time the POC received the call for fire until the time the target was passed to the launcher control station. Mission processing times for targets of opportunity were measured from the time the brigade TOC received the call for fire until the time the target was passed to the launchers.

2. Test Issues

a. *Introduction*

In order to evaluate the command and control procedures for the NLOS system, the test team identified two critical issues that needed to be addressed:

Issue 1. Can the BCC effectively command and control the NLOS weapon system?

Issue 2. Can the BCC effectively command and control NLOS as a dual capable system? [Ref. 11:p. 1-1]

The two issues were further broken down into specific measures of effectiveness (MOE) which could be evaluated by examining the test data. (Although measures of effectiveness are traditionally actual measures of force effectiveness, the testors in the case of the BCCT chose to use the term to identify both measures of effectiveness and subissues of the test.) Issue 1 was broken down into five separate MOE'S, three of which are germane to the purpose of this paper. Issue 2 was subdivided into three MOE's and two are relevant to this discussion. The test data consisted of mission processing times and subject matter expert (SME) observations of test players and test mission events.

b. Issue 1

(1) Measure of effectiveness 1. " What were the mean and median times required for the BCC to process targets?" [Ref. 11:p. 2-1] Although this MOE was said to address both ground and air missions, it only addressed ground missions assigned to NLOS-AT units. No mission processing times were recorded for NLOS-AD units because, as mentioned earlier, no AD test players were involved in BCC mission processing. (The AD platoon leader in the TOC did not process targets because the decision to engage was decentralized down to the gunner.) In the defensive phase, seventy-five targets of opportunity and seventeen engagement area missions were processed. For targets of opportunity, the median processing time was nine minutes and forty-three seconds and the mean processing time was ten minutes and twenty-four seconds. For engagement area missions (both defense and offense) the median processing time was three minutes and two seconds and the mean processing time was three minutes and twenty-three

seconds. In the offensive phase, eighty-four targets of opportunity missions were processed and only one engagement area mission was fired. The median processing time for targets of opportunity was eight minutes and eighteen seconds and the mean processing time was nine minutes and twenty-nine seconds. Analysis of the above mission processing times, along with discussions with field artillery SME's prompted the testors to conclude that the BCC was capable of processing NLOS weapon system fire missions.

(2) *Measure of Effectiveness 2.* "How does the command and control of the NLOS weapon system by the BCC effect planning and coordination functions currently performed by the FSE?" [Ref. 11:p. 2-4] Data collection in support of answering this MOE was obtained exclusively from observations by the field artillery SME in the brigade TOC. The SME observed activities of the FSE during each trial. He was asked to judge the impact of NLOS command and control activities on the planning and coordination functions normally performed by the FSE. The SME noted that while the addition of the NLOS weapon system increased the workload of the FSE considerably, the presence of the AT LNO mitigated the extra burden:

> The proposed NLOS-AT organization adds three more platoons and a new weapon system to the workload. This creates a burden on the FSE. However, if the LNO works properly, the additional workload is manageable. The LNO can keep information on the NLOS-AT operational status, ammunition status, and platoon locations and brief the FSO as required. [Ref. 11:p. 2-5]

Additionally, the SME commented that handling the extra workload was well worth the potential benefits that the new system offered.

(3) *Measure of Effectiveness 3.* "What was the effectiveness of the TTP manual concerning planned missions and targets of opportunity?" [Ref. 11:p. 2-7] SME's and test players were questioned at the end of each of the two test phases concerning the effectiveness of the TTP manual regarding planned missions and targets of opportunity. Many specific comments were made. The general theme was that the engagement area concept for NLOS needs to be redefined. The engagement area concept was only used in 17 of 92 ground missions in the defense and in 1 of 85 missions in the offense. That preplanned missions were not used more often was attributed to the fact that there were just too many engagement areas planned by the brigade TOC (33 in the defense and 17 in the offense). Test players and SME's stated that a smaller number of engagement areas (on the order of 4 or 5 in a brigade sector) would allow the available sensors to monitor all the trigger points and provide a more efficient means to engage preplanned targets. Some said the engagement areas needed to be smaller and some said they should be larger, but all agreed that the issue needs more work. One SME suggested that technical testing should be done utilizing the actual missiles in order to establish what a good NLOS engagement area should look like. The test player who acted as the FSO stated that the "...optimum number of engagement areas should be a force development testing and experimentation (FDTE) issue." [Ref. 11:p. 2-10] No problems were mentioned in regard to the engagement of targets of opportunity.

c. *Issue 2*

(1) Measure of Effectiveness 1. "What were the mean and median times required for the BCC to process NLOS-AT targets serviced by NLOS-AD?" [Ref. 11:p. 3-1] In accordance with the TTP manual, some NLOS-AD missiles were reserved for use in the ground role. Ground targets were assigned to NLOS-AD units when no NLOS-AT units were available to fire and the tactical situation dictated the use of NLOS for fire support. In the defensive phase 17 ground targets were attacked by NLOS-AD. The median mission processing time was eight minutes and thirty-five seconds and the mean was eight minutes and sixteen seconds. NLOS-AD attacked 7 ground targets in the offensive phase. The median mission processing time was five minutes and thirty-three seconds and the mean was seven minutes and twenty-nine seconds. The above times represent slightly faster mission processing times than those recorded for NLOS-AT in the ground role. This was attributed to the fact that NLOS-AD ground targets had to pass through fewer elements. (NLOS-AD ground targets were processed by the brigade S2, the brigade operations section, and the NLOS-AD platoon leader. The BOC was not involved as with NLOS-AT ground targets.) The assessment of this MOE was that NLOS-AD units could assume the ground role with little trouble.

(2) Measure of effectiveness 2. "What were the mean and median times required for the BCC to process NLOS-AD targets serviced by NLOS-AT?" [Ref. 11:p. 3-3] The AD launcher controller passed air targets to the brigade TOC when no AD launchers were available to fire. The FSO made the decision whether or not to engage the air targets with NLOS-AT. A percentage of NLOS-AT missiles were reserved for use in the air role in

accordance with the TTP manual. Only 6 air targets were engaged by NLOS-AT during the entire test. All air engagements occurred in the offensive phase. The test report gives no explanation of why no air targets were engaged by NLOS-AT in the defensive phase, but a likely explanation is that since the offensive phase was the latter phase and no air targets had been engaged up until that point, a conscious decision was made to attempt some NLOS-AT air engagements. The median mission processing time for NLOS-AT against air targets was six minutes and seven seconds and the mean was five minutes and forty-four seconds. The assessment of this MOE was that based on the processing times and the short time normally available to engage fast-moving maneuvering helicopters, NLOS-AT may not be able to effectively assume the air role.

3. Overall Test Results

The BCC test was designed to answer questions invoving two critical issues regarding the command and control of the NLOS weapon system. Because the test was substantially limited due to the lack of actual NLOS weapon systems, sensors, and command and control assets, the test had to rely highly on message processing times as a surrogate measure of effectiveness for the entire command and control system. In terms of the definition of a command and control system, the BCC test was able to evaluate some of the communications, procedures, facilities, personnel and equipment, necessary to command and control NLOS, but some key elements were missing. The test did nothing to measure how well sensors will acquire masked targets and pass them on to the appropriate elements of the command and control system. Launch activities were not incorporated in the test leaving many questions concerning engagement techniques unanswered. The overall test assessments were made with these facts in mind. In regard to whether or not the BCC can effectively command and control the NLOS weapon system, the assessment was, "Although processing times may or may not meet eventual criteria, the brigade is capable of processing NLOS weapon system missions." [Ref. 11:p. 12] This assessment clearly does not answer the question of whether or not the BCC is totally capable of commanding and controlling NLOS, but it is not meant to. As more of the elements of the command and control system become available, subsequent testing will provide a more complete measurement of NLOS command and control.

In regard to the issue of whether or not the BCC can effectively command and control NLOS as a dual capable system, the surrogate measure of mission processing times was again relyed upon heavily. Based largely on the mission processing times for NLOS-AT to process air targets, the overall assessment as far as command and control in the dual role was:

> While NLOS-AD units can assume the NLOS-AT ground role with little trouble, the converse is not necessarily true. The short time available to engage maneuvering helicopters may prevent the NLOS-AT battery from assuming the air role. [Ref. 11:p. 3-6]

The fact that NLOS-AD could process ground missions without much trouble is reason enough to pursue the dual command and control issue in future tests.

V. SUMMARY AND CONCLUSIONS

This thesis has described the NLOS weapon system as an application of fiber optic technology with a dual capability to engage masked rotary wing and armored ground targets. The evolution of the system's proposed employment concept was traced from the time it was originally funded as an integral part of the Army's Forward Area Air Defense System through its current planned use in the dual role at the maneuver brigade level. The NLOS-CA (Combined Arms) concept, as developed by the Combined Arms Development Activity, consisting of NLOS-AD (Air Defense) and NLOS-AT (Anti-tank) components, was proffered as the current employment concept. A discussion of command and control explained how the FAADC2I system will be used to fight NLOS-AD in the air role. The command and control system used to integrate NLOS-AT into the brigade's fire support system for employment in the ground role was discussed, followed by an examination of how the maneuver brigade commander will employ the weapon system in the dual air-ground role. Although the NLOS system has yet to undergo Force Development Test and Experimentation (FDTE), some testing of the proposed command and control system has already provided some useful insights concerning eventual fielding.

Results of the Battle Control Cell Test (BCCT) indicate that employment of the NLOS-CA system at the maneuver brigade level should work with the possible exception of NLOS-AT being used to engage air targets. The fact that it took on the order of five minutes to process air targets for assignment to NLOS-AT indicates that the responsiveness of NLOS-AT in the air role is not sufficient. The fact that mission processing times for NLOS-AD and NLOS-AT in the ground role were both on the order of eight to nine minutes supports the conclusion that NLOS may be employed successfully as a dual capable system in the ground role.

The employment of NLOS-AD in the air role is heavily contingent on the development and successful integration of masked target sensors into the FAADC2I system. Due to the fleeting nature of the helicopter threat, NLOS-AD must be provided real time target data to enable the gunner to fly the missile to the target. Tests have thus far (by necessity) surrogated the FAADC2I system and assumed that masked helicopters will be detected and passed on in a timely manner. Until this capability is actually demonstrated, judgement on the capability of NLOS-AD against the air threat should be withheld.

Although the Battle Control Cell Test was able to provide some useful insights concerning mission processing times and the use of engagement areas, much more testing needs to be done. The lack of weapon system hardware and proposed automated command and control systems for the NLOS system precludes a definitive evaluation of command and control at this time. The fact that doctrine, tactics, and command and control procedures have already been developed and refined for NLOS will aid greatly in future testing.

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